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# Report on stakeholder choice validation using a Choice Experiment

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SEVENTH FRAMEWORK PROGRAMME

# Report on stakeholder choice validation using a Choice Experiment

**Wahara Deliverable - 2.4**

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## List of Abbreviations

| | |
|---|---|
| ASC | Alternative specific constant |
| CE | Choice experiment |
| C.I. | Confidence interval |
| DT | Dinar Tunisien (Currency Tunisia) |
| EM | Effective micro-organisms |
| FCFA | Franc CFA (Currency Burkina Faso) |
| FLL | Final log-likelihood |
| K | (Zambian) Kwacha (Currency Zambia) |
| SS | Study site |
| WH | Water harvesting |
| WHT | Water harvesting technology |
| WP | Work package |
| WTP | Willingness to pay |

# 1 Introduction

Water harvesting technologies (WHT), despite being advocated as versatile low-cost measures enabling agricultural intensification, enhancing food and water security of rural populations, and adapting to current climate variability and future climate change (e.g. Zougmoré et al., 2014), is still predominantly practiced in relatively confined areas where technologies have either been developed over time through local innovation or intensively trialled and promoted by development actions. Important questions regarding the limited evidence for scaling out of such experiences tend to point to a lack of consideration of social, economic and political contexts, notably overlooking the needs, preferences and aspirations of the farming population being targeted (Oweis and Hachum, 2006).

Although social, economic and political conditions necessary for water harvesting (WH) are qualitatively known, no quantification has been made yet to understand and support individual decisions by farmers (Vohland and Barry, 2009). Given that socio-economic factors and stakeholder preferences are pivotal factors determining the potential for success of WH technologies, participatory methods must be adopted to monitor and evaluate WH technologies. For instance, it is important to understand how farmers conceptualize risk (Ngigi et al., 2005). While WH technologies generally reduce risks (e.g. of crop failure), risks are not eliminated. For resource-poor people investing financially in a technology itself constitutes a considerable risk. Low- or no-cost WH technology has generally found more uptake, and promoting technologies without discussing risks has left many adopters disillusioned (Ngigi et al., 2005). Decision-making preferences must be thoroughly understood before WHT can be successfully disseminated.

Moreover, some decision-making preferences might vary strongly among stakeholders and yet the workshop procedure, as a qualitative method, may not yield robust conclusions regarding this variability. The participatory selection process of technologies for testing in the stakeholder workshops (WP2 Task 2.4) can result in a selection prone to biases inherent to the process (innovators are actively recruited and likely overrepresented, stakeholder representation may be uneven, and the selection process may itself have a dynamic of its own, influencing outcome). It is moreover a qualitative method which cannot be used to extrapolate findings to a larger population. The latter is important to understand the potential for adoption of technologies. Therefore, in Task 2.5 a choice experiment (CE) was designed for individual stakeholders to analyse stakeholder preferences based on attributes of WH technologies and decision-making. This choice experiment allowed validation of the participatory selection process and assessment of the potential for WH technology adoption in the study site. In Task 2.6, the choice experiment was subsequently implemented in each study site, resulting in a rich dataset requiring a substantial analysis effort. Next to validating the participatory selection process, results will be used to characterise stakeholder decision-making in the economic model of WP4.

Choice experiments have been widely applied in environmental management (e.g. Hanley et al., 1998; Wattage et al., 2005; Colombo et al., 2006; García-Llorente et al., 2012; Drake et al., 2013). Few CE studies have looked specifically at preferences for agricultural innovations specifically (e.g. Blazy et al., 2011), and none that we are aware of have studied WHT specifically. By combining the choice experiment with a short questionnaire, determinants of farmer's choices can be explored as well (Adimassu et al., 2012). Indeed, heterogeneity in preferences among populations has been one of the key aspects studied with choice experiments (Beharry-Borg et al., 2013).

Choice experiments (CE) elicit preferences for each of the alternatives (in this case water harvesting technologies) in a choice set, where the alternatives are characterised by different attributes (criteria) and their levels. In order to obtain these preferences, a respondent is presented with a series of choice sets of the available alternatives along with the attributes that characterise them. These series of choice sets presented to the respondents form the choice scenarios which vary based on the levels of the attributes. A choice scenario is a hypothetical situation depicting a set of alternatives and the associated attribute levels on which a respondent is asked to choose. Each CE comprises of several choice scenarios, each of which represents a hypothetical choice situation. The number of choice scenarios presented to the respondents is determined by the method of the experimental design. The respondents in a CE are expected to make trade-offs between different combinations of the attributes and select an alternative (or the status quo option, if that is provided) for each of the choice scenarios. As the method of the CE involves eliciting respondents' preferences over a series of choice scenarios, it is important to keep the number of these choice scenarios to an optimum level in order to obtain as much data as possible without encountering discrepancies in respondents' choice due to fatigue arising from participating in numerous choice scenarios. The number of choice scenarios is dependent on the number of alternatives, the number of attributes and attribute levels as well as the type of experimental and survey design.

This report explains the design of the CE survey conducted in all four WAHARA study sites, and presents the results from the analyses. Section 0 provides details on the methods followed, Section 0 presents the results of choice models per study site while Section 0 discusses the results and conclusions are summarized in Section 0.

# 2 Methods

The CE comprises of the following main components – the alternatives presented to the respondents, the attributes that characterise each of the alternatives, the different levels of the attributes and the number of choice scenarios over which the respondents are asked to make a choice. In order to implement a successful CE design, the following considerations needs to be taken:

- The choice scenarios need to vary from one another based on the level of the attributes that characterise each alternative

- In order to design a CE that is easy for respondents to understand, it is important that the attribute levels across the different alternatives in a choice set vary markedly

- It is necessary to select those attributes in a CE which are important and which needs to be valued in the project

- While the CE projects several hypothetical scenarios under which the respondents are asked to make a choice, it is nonetheless important that the attribute levels provided to the respondents in the CE are as realistic as possible

- In order to keep the number of choice scenarios reasonable so as to avoid fatigue effects, it is important that the number of alternatives, attributes as well as the attribute levels are selected carefully and very large numbers are avoided as this would substantially increase the number of choice scenarios required in the CE survey

Under the specific context of the selection of a preferred water harvesting technology (WHT) and the estimation of the attributes/criteria that are important in the decision-making using the CE method, the attributes selection for the CE can follow from the criteria chosen by the stakeholders in the stakeholders' workshop from each study site (SS). However, the considerations given above for the CE experimental design do need to be taken into account.

While in order to compare the CE studies across sites it is desirable to have as much similarity between the CE designs as possible, this can be achieved by implementing a CE survey that broadly incorporates the same criteria across the different study sites (unless a particular site-specific criterion which needs to be included in the CE is very significant to evaluate and markedly different from others). Though it is expected that some of the criteria selected by the stakeholders across the different SS would be the same, it is imperative to examine whether there are any site specific variations and whether the CE design needs to be modified based on this consideration. It is also important to examine in the stakeholders' workshop which attribute representation methods are most suitable under each study site context and incorporate these factors in the CE design and implementation (for example, whether the increase in crop yield is best presented to the stakeholders in terms of absolute value or as a percentage change in the crop yield). Thus, the researchers in the stakeholders' workshop should aim to seek if possible, which method of representing or explaining a criterion is easiest for the participants to understand.

The CE alternatives presented to the stakeholders can either be 'labelled' or 'unlabelled' as specific WHT. In case of the 'labelled' method of representing the alternative, each of the alternatives in the CE is specified as is known to the respondent (such as, 'planting pits', 'hillside reservoir' etc.) while in case of the 'unlabelled' representation, the alternatives are distinctly specified as 'WHT 1', 'WHT 2' and so on. Each of these methods of specifying the alternatives offer different advantages. While the 'labelled' alternative makes it clearer for the stakeholders to understand which WHT are considered within the choice set, the use of 'unlabelled' alternatives can discourage the stakeholders to apply any preconceived ideas about the specific WHT to influence their decision-making.

Following the stakeholders' workshop which aimed to select 2-3 alternatives to be included in the choice experiment along with the necessary attributes, the SS partners provided the CE team with the selected alternatives to be included in the CE along with the different levels that the attributes can take. Each study site selected an indigenous WHT and a new WHT, along with any status quo alternative to be tested with the CE, following the discussion on what needs to be included in the CE. The attributes selected for the CE survey across the four study sites were: increase in crop yield, cost and risk of crop failure. As the cost attribute comprised of investment and maintenance costs, this took the form of annuity cost in case of three study sites except Zambia. In the case of Zambia the annuity cost was not considered to be meaningful and the investment and maintenance costs were provided separately in the CE survey (see Section 2.3.4 for further elaboration).

Based on the information provided by the SS partners on the alternatives and the attribute levels, a CE was designed for each of the study sites. In order to have as much similarity as possible in the CE design across the study sites, similar methods of CE design were employed across the study sites. Moreover, the SS partners were encouraged to follow a uniform CE implementation method, provided to them.

An example of a CE is given in Annex B which highlights the type of different choice scenarios, alternatives, attributes and their levels that can be incorporated within a survey to validate stakeholders' selection of WHT.

## 2.1. Alternatives

The alternatives selected for each of the study sites can be broadly classified into three main categories: indigenous WHT (alternative A), new/introduced WHT (alternative B) and the status quo. The alternatives included in the CE followed from the stakeholders' workshop. Based on whether the farmers already have some WHT in place or do not have a WHT, the status quo alternative comprised of WHT, multiple WHT or no WHT.

In case of each of the study sites, the following alternatives were selected:

**Table 1 Overview of alternatives and attributes for each study site**

| | **Indigenous WHT (Alternative A)** | **New WHT (Alternative B)** | **Status quo (Alternative C)** |
|---|---|---|---|
| Burkina Faso | Zai and Stone bunds | Magoye ripper | No WHT |
| Ethiopia | Check dams | Soil improvement with EM | Multiple/no WHT |
| Tunisia | Jessour/Tabia | Jessour/Tabia with Zai | Current WHT |
| Zambia | Conservation farming with Magoye ripper | Conservation farming with strip tillage | No WHT |

It can be seen that in the case of Burkina Faso and Zambia, the 'no WHT' formed the status quo while in case of Ethiopia, the status quo alternative could comprise of one, multiple or none WHT, depending on the farmer. In the case of Tunisia, the current WHT that the farmer has, comprised the status quo alternative.

## 2.2. Attributes

### *2.2.1. Increase in crop yield*

This attribute represents the increase in crop yield that can incur after the selection of a particular WHT. It is based on the range of crop yield given by the study site partners. The levels of the increase in crop yield can be based on variation in the farm areas, the different rainfall years or other criteria. The increase in crop yield is given in kilogram/ha or tonne/ha.

### *2.2.2. Risk of crop failure*

The risk of crop failure attribute is based on the probability of the occurrence of the factor/s of crop failure (such as rainfall), and the probability of risk of crop failure. To compute the attribute levels, the study site partners were asked to provide probability of the factor of the risk of crop failure (which was recognised as the type of rainfall year, in all cases). Thus the study site partners provided the probability of wet, normal and dry rainfall years for the past five years along with the probability of high, medium and low risks of crop failure for each of the rainfall year types. The following classification was used to form the linguistic levels of the risk of crop failure attribute:

High risk of crop failure: > 60% crops fail
Medium risk of crop failure: 40-60% crops fail
Low risk of crop failure: <40% crops fail

### 2.2.3. *Annuity cost*

The cost attribute was included in the CE to get a monetary value of the other attributes. As the WHTs involve maintenance as well as investment costs due to the lifetime of the WHTs spread over one to several years, annuity cost was selected as the cost attribute. In case of Zambia however, the maintenance and investment costs were individually incorporated in the CE design as the selected alternatives required none or yearly maintenance.

The annuity cost was calculated based on the rate of interest and the life of the WHT, as provided by the study sites. This was calculated using the following formula:

$$\frac{I + M\left(\left(1-(1+r)^{-t}\right)/r\right)}{t}$$

Where, *I* = investment cost
*M* = maintenance cost
*r* = rate of interest
*t* = time period

## 2.3. CE experimental design

A difference design was used in the fractional factorial orthogonal design to develop the CE scenarios. The full factorial design is based on the factorial count of all possible combinations of attribute levels which significantly increases the number of choice scenarios required in the CE. The fractional factorial design includes a very small number of choice scenarios in the CE survey, which is a fraction of the full factorial design. This small fraction has the ability to sufficiently reflect the preferences captured by the full factorial design. Orthogonal designs ensure that there is no correlation between the attributes.

With the difference design the number of choice scenarios required in the CE survey is substantially reduced as the difference between the attribute levels across the alternatives is considered when designing the CE. In case of a CE with two alternatives, this reduces the number of choice scenarios required to half relative to the case of a CE design where both the alternatives are considered individually to design the CE.

The number of choice scenarios required with the full factorial design can be given as:

$$L^{M \times N}$$

where,
L = number of attribute levels
M = number of alternatives
N = number of attributes

Thus, in the case where there are two attribute levels, two alternatives and three attributes, the number of choice scenarios required with the full factorial design will be $2^{2\times3} = 64.$ It can thus be observed that although the number of attribute levels, number of alternatives and number of attributes are not very high in this case, the full factorial design yields a very high number of choice scenarios required for the CE. Hence, the fractional factorial design is more often used which provides an optimal number of choice scenarios required for the CE from the complete list of the full factorial design. Using the above given number of attribute levels, alternatives and the attributes, a fractional factorial orthogonal design using the design given in Kocur (1982) would require 16 choice scenarios (Ibáñez et al., 2007).

One method to further reduce the number of choice scenarios is to use the difference design method. With the difference design method, the differences between the attribute levels across the alternatives are considered as one level. Thus, in case of two alternatives, the difference between attribute level $x_1$ of alternative 1 and $x_2$ of alternative 2 is taken as one level 'x', for the design of the experiment. Using the above example of two attribute levels, two alternatives and three attributes, the difference design would yield $2^{1\times3} = 8$ choice scenarios. This is because the difference in the attribute levels across alternatives is considered in the design, effectively reducing the number of alternatives to one.

A difference in the attributes levels across alternatives A and B was considered for the fractional factorial orthogonal difference design. Based on the number of attributes and attribute levels for each study site, 8-9 choice scenarios were developed for each of the study sites, considering two alternatives A and B. The status quo alternative was then incorporated into each choice scenario. As the attribute levels of status quo alternative varied for each farmer, this alternative was not specifically included in the CE design process. The following sections provide an outline of the CE alternatives and attributes for each of the study sites:

### *2.3.1. Burkina Faso*

In case of Burkina Faso, zai and stone bunds were selected as the 'indigenous' WHTs (alternative A) while Magoye ripper was selected as the 'new' WHT (alternative B) and 'No WHT' comprised the status quo alternative. Based on the information provided by the study site partner, the attribute levels used in the CE design can be summarised as follows:

**Table 2 CE attribute levels - Burkina Faso**

| | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| **Crop yield** | | | |
| Zai and stone bunds | 0-800 kg/ha | 800-1800 kg/ha | 1800-2400 kg/ha |
| Magoye ripper | 0-500 kg/ha | 500-1500 kg/ha | 1500-2100 kg/ha |
| Status quo | 400 kg/ha | 400 kg/ha | 400 kg/ha |
| **Annuity cost** | | | |
| Zai and stone bunds | 15000 FCFA/ha | 30000 FCFA/ha | 45000 FCFA/ha |
| Magoye ripper | 12000 FCFA/ha | 15000 FCFA/ha | 20000 FCFA/ha |

| | | | |
|---|---|---|---|
| Status quo | As now | As now | As now |
| **Risk of crop failure** | | | |
| Zai and stone bunds | High in normal year | Medium in normal year | Low in normal year |
| Magoye ripper | Medium in normal year | Low in normal year | High in normal year |
| Status quo | As now | As now | As now |

### *2.3.2. Ethiopia*

Check dams was selected as indigenous WHT to be tested with CE while soil improvement with EM (effective micro-organisms) was selected as the new WHT. The status quo alternative comprised of multiple/no WHT. The following attribute levels were considered in the CE, based on the information provided by the study site:

**Table 3 CE attribute levels - Ethiopia**

| | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| **Crop yield** | | | |
| Check dams | >15 quintal/ha | 10-15 quintal/ha | <10 quintal/ha |
| Soil improvement with EM | 10-20 quintal/ha | <10 quintal/ha | >20 quintal/ha |
| Status quo | As now | As now | As now |
| **Annuity cost** | | | |
| Check dams | 4600 Birr | 2700 Birr | 900 Birr |
| Soil improvement with EM | 2850 Birr | 3800 Birr | 1900 Birr |
| Status quo | As now | As now | As now |
| **Risk of crop failure** | | | |
| Check dams | Low in wet year | High in dry year | Medium in normal year |
| Soil improvement with EM | Low in wet year | Medium in dry year | Low in normal year |
| Status quo | As now | As now | As now |

### *2.3.3. Tunisia*

The alternative selected for the CE survey were Jessour/Tabia as indigenous WHT and Jessour/Tabia with Zai as ‘new’ WHT. While the current WHT situation comprised the status quo alternative.

The attribute levels in case of Tunisia are as follows:

**Table 4 CE attribute levels - Tunisia**

| | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| **Crop yield** | | | |
| Jessour/Tabia | 3600 kg/ha | 7800 kg/ha | 600 kg/ha |
| Jessour/Tabia with Zai | 4440 kg/ha | 14400 kg/ha | 600 kg/ha |
| Status quo | As now | As now | As now |
| **Annuity cost** | | | |
| Jessour/Tabia | Dt 166 | Dt 305 | Dt 445 |

| | | | |
|---|---|---|---|
| Jessour/Tabia with Zai<br>Status quo | Dt 185<br>As now | Dt 331<br>As now | Dt 477<br>As now |
| **Risk of crop failure**<br>Jessour/Tabia<br>Jessour/Tabia with Zai<br>Status quo | <br>Low in wet year<br>Low in wet year<br>As now | <br>Medium in average year<br>Low in average year<br>As now | <br>High in dry year<br>Medium in dry year<br>As now |

### *2.3.4. Zambia*

Conservation farming with Magoye ripper formed the indigenous WHT and Conservation farming with strip tillage formed the new WHT while the status quo alternative comprised of 'no WHT'. The following attribute levels were incorporated in the CE survey:

**Table 5 CE attribute levels - Zambia**

| | **Level 1** | **Level 2** | **Level 3** |
|---|---|---|---|
| **Crop yield**<br>CF with Magoye ripper<br>CF with strip tillage<br>Status quo | <br>2 tonne/ha<br>3 tonne/ha<br>As now | <br>3 tonne/ha<br>4 tonne/ha<br>As now | <br><br>None<br> |
| **Investment cost**<br>CF with Magoye ripper<br>CF with strip tillage<br>Status quo | <br>2550 K<br>2034 K<br>As now | <br>2235 K<br>2350 K<br>As now | <br><br>None<br> |
| **Maintenance cost**<br>CF with Magoye ripper<br>CF with strip tillage<br>Status quo | <br>100 K<br>0 K<br>As now | <br>100 K<br>0 K<br>As now | <br><br>None<br> |
| **Risk of crop failure**<br>CF with Magoye ripper<br>CF with strip tillage<br>Status quo | <br>High<br>Low<br>As now | <br>Medium<br>High<br>As now | <br>Low<br>Medium<br>As now |

## 2.4. Choice Modelling Method

The CE models comprise of the utility functions for each of the alternatives included in the CE survey. The choice models are based on the random utility maximisation theory, which states that individuals choose alternatives based on utility maximisation. The random utility comprises of a deterministic component and a stochastic component (random error). As the stochastic component of an individual cannot be known with certainty, which alternative will be selected by an individual cannot be certainly known. However, using the distribution of the error term, the probability of an individual's choice can be computed (Koppelman and Bhat, 2006).

The deterministic component of the choice model comprise of the attributes and its coefficient. This coefficient is statistically estimated by the model. Based on the choices made by the respondent as well as the specification of the model characteristics, the model and the attribute coefficients are estimated.

The utility functions for each of the models signify the functional form of the attributes while the coefficient estimates denote the effect the attribute has on the model fit. Based on the assumptions made about the behaviour of the respondents, different utility functions can be specified. However, in all cases a linear functional form of the attributes is assumed. As farmers are expected to view the increase in yield and the reduction in the risk of crop failure positively, these attributes are expected to yield a positive coefficient estimate in the analysis. However, the cost attribute is expected to have a negative coefficient estimate as it is considered to be a disutility.

A typical utility function in the choice model can include an alternative specific constant (ASC), which represents the mean distribution of the unobserved effects on the alternative (Louviere et al., 2000) along with the functional form of the attributes.

The segmentation models examine the effect that a selected socio-economic variable has on the choice of a particular alternative. Segmentation models are conducted in relation to a base value of the socio-economic variable. The segmentation is applied to *(n-1)* alternatives of the choice model. Thus, in case of the income variable for example, the segmentation can be conducted in relation to the low income category and applied to the WHT alternatives (alternatives A and B). The results from the segmentation analyses will reveal how farmers with higher income categories (in relation to the base category of low income) choose the WHT alternatives.

The interaction models reveal how the socio-economic variables interact with the choice model variables. Thus, in order to examine how income level affects the choice of the high yield variable, an interaction model can be conducted where coefficient estimates are obtained for the interaction of the income category with the high yield category (thus a coefficient estimate is obtained for a product of the income category and the high yield category).

From the choice modelling analysis, several outputs are obtained. These include the attribute coefficient estimates and their statistical significance, the rho square and the adjusted rho square values and the final log-likelihood. The final log-likelihood (FLL) and the rho square values provide an estimate of the model fit. The closer the FLL is to zero, the better the model fit. In case of the rho and adjusted rho square values also, a higher value is considered better. The adjusted rho square value considers the number of parameters estimated (Bierlaire, 2008) and is hence used for model comparison over the rho square values.

From the attribute coefficient estimates from the choice model, the amount a farmer is willing to pay for a particular attribute can be estimated. For example, the willingness to pay for high yield can be calculated as follows:

$$WTP_{high\ yield} = -\frac{\beta_{high\ yield}}{\beta_{cost}}$$

The WTP estimate is useful in policy decisions that are based on the monetary value that respondents give to selected attributes.

# 3 Results

The results per study site can be classified in to three sections: the descriptive statistics which gives an overview of the respondent characteristics, the base choice models which do not incorporate the socio-economic characteristics of the respondents and the segmentation and interaction models which incorporate farmers' socio-economic characteristics. The choice models are estimated using Biogeme 2.0 (Bierlaire, 2003). All models are estimated considering panel effects by incorporating an alternative specific error component in *(n-1)* alternatives. The panel model accounts for correlation among choices from the same respondent (Abdel-Aty et al., 1997; Yanez et al., 2010).

For each of the study sites, only those results are presented here which are statistically significant. Hence it is observed that in some cases, more segmentation and interaction results are outlined than in others. This is due to the increased effect of socio-economic factors on the choice model in these cases.

All WTP estimates in Euro are given according to the exchange rate as on 27 April 2015.

The following table provides an overview of the different models analysed for each of the study sites:

**Table 6 An overview of CE analyses performed and reported**

| | **Base Models** | **Segmentation models** | **Location model** | **Interaction models** |
|---|---|---|---|---|
| **Burkina Faso** | Performed, reported | Performed, not significant | Not performed | Performed, not significant |
| **Ethiopia** | Performed, reported | Performed, partly reported | Not performed | Not performed |
| **Tunisia** | Performed, reported | Performed, partly reported | Performed, reported | Performed, reported |
| **Zambia** | Performed, reported | Performed, partly reported | Not performed | Performed, not reported |

The results for each study site are given in the following sections.

## 3.1. Burkina Faso

Descriptive Statistics:

The descriptive statistics provide an outline on the socio economic characteristics of the farmers along with their perception on the importance of the WHTs, the suitability of WHTs and whether they are responsible for managing their own or others' farms, along with the information on whether they already have some WHT currently in place.

As the responsibility of managing own and others' farms are independent from each other, it can be seen that the total of these two factors is greater than 100%. In case of Burkina Faso, farmers consider several WHTs as suitable to their needs and hence in this case, the sum of the suitability of WHTs is also greater than 100%. In case of the other variables, the sum equals 100%.

The descriptive statistics reveal that all farmers are responsible for managing their own farm while about a quarter farmers are also responsible for managing others farms. About half of the farmers consider WHTs to be very important for their farming needs while 27% farmers consider it to be 'important'. Zai and stone bunds were considered to be very suitable WHTs with significant importance also given to grass strips and half-moons. Almost all farmers currently have some WHT in place. About 75% farmers were found to have no primary education while almost half of the farmers belong to the age group 26-40. Most farmers were found to have medium to high income and 99% of farmers were employed as full-time farmers. About 70% farmers chose alternative B in the choice experiment while 26% farmers chose alternative A. The following table provides a summary of the descriptive statistics for Burkina Faso:

**Table 7 Burkina Faso descriptive statistics for some kry socio-economic variables**

| Variable | Frequency (n = 100) | Percentage |
|---|---|---|
| **Responsible for managing farms*** | | |
| - Own farm | 100 | 100% |
| - Others' farm | 26 | 26% |
| **Importance given to WHT** | | |
| - Very Important | 52 | 52% |
| - Important | 27 | 27% |
| - Neither important nor unimportant | 16 | 16% |
| - Unimportant | 3 | 3% |
| - Very unimportant | 2 | 2% |
| **Suitability of water harvesting technologies*** | | |
| - Zai suitability | 97 | 97% |
| - Stone bunds suitability | 95 | 95% |
| - Grass strip suitability | 73 | 73% |
| - Half-moons suitability | 61 | 61% |
| - No answer | | |
| **Currently own some WHT** | 98 | 98% |
| **Education** | | |
| - Illiterate | 75 | 75% |
| - Primary | 22 | 22% |
| - Secondary | 3 | 3% |
| - Graduate | 0 | 0% |
| - Post graduate | 0 | 0% |
| **Age** | | |
| - 18-25 | 8 | 8% |
| - 26-40 | 48 | 48% |
| - 41-55 | 33 | 33% |
| - 56-75 | 11 | 11% |
| - 75 + | 0 | 0% |
| **Gender** | | |
| - Male | 62 | 62% |

| | | |
|---|---|---|
| - Female | 38 | 38% |
| **Income**<br>- < 1000<br>- 1001 – 3000<br>- 3001 – 5000<br>- > 5000 | <br>10<br>25<br>40<br>25 | <br>10%<br>25.1%<br>39.9%<br>25% |
| **Employment**<br>- Full time<br>- Part time<br>- Unemployed<br>- Retired<br>- House work<br>- Farm work | <br>1<br>0<br>0<br>0<br>0<br>99 | <br>1%<br>0%<br>0%<br>0%<br>0%<br>99% |
| **Choice (n = 900)**<br>- Alternative A (Zai, Stone bunds)<br>- Alternative B (Magoye ripper)<br>- Status quo (No WHT)<br>- No choice/missing value | <br>238<br>636<br>26<br>0 | <br>26.4%<br>70.7%<br>2.9%<br>0% |

*Variables with multiple possible responses per respondent (total can exceed 100%)

Base Models:

- **Base model without incorporating status quo variables:** a base model was specified with the status quo alternative equalling an alternative specific constant and without the incorporation of the farmers' current crop yield, perceived risk of crop failure and current WHT cost in the status quo utility function. This was done in order to incorporate any factors affecting the choice of the status quo alternative into the model through the status quo ASC. The rationale to conduct two different models, with and without the status quo variables, was to examine whether the respondents actively consider the characteristics of their current WHT to inform their decision-making.

  As the levels for the risk of crop failure were the same for the alternatives A and B, the same coefficient estimates were considered in case of this attribute level for alternatives A and B. The utility functions took the following form:

$$U_A = \alpha_1 medium\ Yield\ A + \alpha_2 high\ Yield\ A + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma CostA$$

$$U_B = ASC_B + \alpha_1 medium\ Yield\ B + \alpha_2 high\ Yield\ B + \beta_1 low\ risk\ of\ crop\ failure\ B + \beta_2 medium\ risk\ of\ crop\ failure\ B + \gamma CostB$$

$$U_c = ASC_C$$

  The following results were obtained for this model:

**Table 8 Multinomial logit model without status quo variables**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|

| | | | |
|---|---|---|---|
| ASC – alternative B | 1.13 (6.98) | | |
| ASC – alternative C | -7.46 (-4.73) | | |
| Medium yield | -1.21 (-1.00) | 271910.11 (0.46) | 414.52 (0.46) |
| High yield | -3.95 (-3.55) | 887640.45 (0.51) | 1353.20 (0.51) |
| Low risk of crop failure | -0.220 (-1.93) | 49438.20 (0.50) | 75.37 (0.50) |
| Medium risk of crop failure | -0.414 (-3.83) | 93033.71 (0.51) | 141.83 (0.51) |
| Cost | 0.00000445 (0.52) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.406<br>0.397 | | |
| FLL | -587.057 | | |
| No. of observations | 900 | | |
| No. of individuals | 100 | | |

The above results reveal that the attribute coefficients are wrongly signed which could indicate that the respondents might not have undergone the CE trade-off as expected in the exercise. The ASC for alternative B is significant and positive while the descriptive statistics reveal that about 70% farmers choose this alternative which indicates that the farmers choose the alternative without making the required trade-offs between the attributes of the different alternatives. As alternative B has a lower annuity cost than alternative A for all the scenarios, the farmers might have chosen this alternative based on the annuity cost attribute.

- **Base model with cost variable:** a base model was specified with the status quo alternative equalling a constant and without the incorporation of the farmers' current crop yield, perceived risk of crop failure and current WHT cost in the status quo utility function. The utility functions took the following form:

$$U_A = \gamma_1 CostA$$
$$U_B = ASC_B + \gamma_2 CostB$$
$$U_c = ASC_C$$

The following results were obtained for this model:

**Table 9 Multinomial logit model without status quo variables with only cost attribute**

| Variable | Coefficient estimate (t-stats) |
|---|---|
| ASC – alternative B | -0.912 (-1.47) |
| ASC – alternative C | -2.47 (-2.61) |
| Cost – alternative A | 0.0000637 (3.12) |
| Cost – alternative B | 0.000248 (3.35) |
| $\rho^2$<br>adj. $\rho^2$ | 0.386<br>0.380 |
| FLL | -607.180 |
| No. of observations | 900 |

| | |
|---|---|
| No. of individuals | 100 |

The results indicate that the cost variables across both the alternatives have a positive and significant value, implying that the farmers do not consider the cost as a disutility. Moreover, this is more pronounced in case of alternative B, where the cost coefficient has a higher and more significant value.

- **Base model with status quo variables:** a base model with yield, risk of crop failure and cost attributes included in the status quo alternative took the following utility function:

$$U_A = \alpha YieldA + \beta_1 low\,risk\,of\,crop\,failure\,A + \beta_2 medium\,risk\,of\,crop\,failure\,A + \gamma CostA$$
$$U_B = ASC_B + \alpha YieldB + \beta_1 low\,risk\,of\,crop\,failure\,B + \beta_2 medium\,risk\,of\,crop\,failure\,B + \gamma CostB$$
$$U_c = ASC_C + \alpha YieldC + \beta_1 low\,risk\,of\,crop\,failure\,C + \beta_2 medium\,risk\,of\,crop\,failure\,C + \gamma CostC$$

The attributes for the status quo alternative were based on the farmers' current crop yield, the perceived risk of crop failure (calculated based on the farmers' perception of the crop yield category from bad to good for the past four year) and the farmers' annuity cost for the current WHT that they have.

The following coefficients were obtained for the variables for this model specification:

**Table 10 Multinomial logit results with status quo variables**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| ASC – alternative B | 1.14 (7.03) | | |
| ASC – alternative C | -6.02 (-4.69) | | |
| Medium yield | -1.36 (-1.70) | 263565.9 (0.57) | 401.80 (0.57) |
| High yield | -3.91 (-4.36) | 757751.9 (0.59) | 1155.19 (0.59) |
| Low risk of crop failure | -0.227 (-2.00) | 43992.25 (0.57) | 67.07 (0.57) |
| Medium risk of crop failure | -0.412 (-3.82) | 79844.96 (0.59) | 121.72 (0.59) |
| Cost | 0.00000516 (0.60) | | |
| $\rho^2$<br>adj. $\rho^2$ | 0.409<br>0.399 | | |
| FLL | -584.795 | | |
| No. of observations | 900 | | |
| No. of individuals | 100 | | |

As the cost coefficient as well as the other attribute coefficients in the above results are wrongly signed, the WTP is still positive; however, it is not reliable in this case.

The above analyses reveal that in case of Burkina Faso, the farmers might not have gone through the CE as expected.

## 3.2. Ethiopia

### Descriptive Statistics:

The descriptive statistics reveal that about 92% farmers are responsible for managing their own farms. Most farmers believe that WHTs are very important. However, about 56% farmers did not specifically choose any WHT as suitable to their needs though 20% consider Eila as a suitable WHT and 22.6% consider Horeye suitable. Most farmers either have no or primary education while the age is about evenly distributed within the age groups in the range 26-75. About 65% farmers have income <1000 Birr per month while most of them are employed as full-time farmers. The farmers choose alternative A and B about evenly, with very few choices of the status quo alternative. The following table provides the results from the descriptive statistics:

**Table 11 Ethiopia descriptive statistics for some key socio-economic variables**

| Variable | Frequency (n = 124) | Percentage |
|---|---|---|
| **Responsible for managing farms*** | | |
| - Own farm | 114 | 91.9% |
| - Others' farm | n.a. | n.a. |
| **Importance given to WHT** | | |
| - Very Important | 120 | 96.8% |
| - Important | 4 | 3.2% |
| - Neither important nor unimportant | 0 | 0% |
| - Unimportant | 0 | 0% |
| - Very unimportant | 0 | 0% |
| **Suitability of water harvesting technologies** | | |
| - Banker suitability | 1 | 0.8% |
| - Baska suitability | 1 | 0.8% |
| - Eila suitability | 25 | 20.2% |
| - Horeye suitability | 28 | 22.6% |
| - No answer | 69 | 55.6% |
| **Currently own some WHT** | 56 | 45.2% |
| **Education** | | |
| - Illiterate | 63 | 50.8% |
| - Primary | 52 | 41.9% |
| - Secondary | 9 | 7.3% |
| - Graduate | 0 | 0% |
| - Post graduate | 0 | 0% |
| **Age** | | |
| - 18-25 | 4 | 3.2% |
| - 26-40 | 37 | 29.8% |
| - 41-55 | 47 (missing 1) | 37.9% |
| - 56-75 | 35 | 28.2% |

| | | |
|---|---|---|
| - 75 + | 1 | 0.8% |
| **Gender**<br>- Male<br>- Female | <br>92<br>32 | <br>74.2%<br>25.8% |
| **Income**<br>- < 1000<br>- 1001 – 3000<br>- 3001 – 5000<br>- > 5000 | <br>81<br>36<br>5<br>2 | <br>65.3%<br>29.0%<br>4.0%<br>1.6% |
| **Employment**<br>- Full time<br>- Part time<br>- Unemployed<br>- Retired<br>- House work<br>- Farm work | <br>5<br>9<br>0<br>0<br>0<br>110 | <br>4.0%<br>7.3%<br>0%<br>0%<br>0%<br>88.7% |
| **Choice (n = 1116)**<br>- Alternative A (Check dams)<br>- Alternative B (Soil improvement with EM)<br>- Status quo (Multiple WHT)<br>- No choice/missing value | <br>492<br>622<br>2<br>0 | <br>44.1%<br>55.7%<br>0.2%<br>0% |

*Variables with multiple possible responses per respondent (total can exceed 100%)

- **Base model without incorporating status quo variables:** a base model was specified with the status quo alternative equalling a constant and without the incorporation of the farmers' current crop yield, perceived risk of crop failure and current WHT cost in the status quo utility function. The utility functions took the following form:

$$U_A = \alpha_1 mediumYieldA + \alpha_2 highYieldA + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma CostA$$

$$U_B = ASC_B + \alpha_1 mediumYieldB + \alpha_2 highYieldB + \beta_1 low\ risk\ of\ crop\ failure\ B + \beta_2 medium\ risk\ of\ crop\ failure\ B + \gamma CostB$$

$$U_c = ASC_C$$

The following results were obtained for this model:

**Table 12 Multinomial logit model without status quo variables**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| ASC – alternative B | -4.41 (-10.3) | | |
| ASC – alternative C | -11.2 (-0.36) | | |
| Medium yield | 0.5 (2.89) | 5555.56 (1.12) | 250.09 (1.12) |
| High yield | 0.0165 (0.11) | 183.33 (0.11) | 8.25 (0.11) |
| Low risk of crop failure | 13.0 (13.45) | 144444 (0.98) | 6502.17 (0.98) |
| Medium risk of crop failure | 5.57 (11.99) | 61888.9 (0.98) | 2786.28(0.98) |

| | | | |
|---|---|---|---|
| Cost | -0.00009 (-0.97) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.722<br>0.715 | | |
| FLL | -339.891 | | |
| No. of observations | 1114 | | |
| No. of individuals | 124 | | |

The results indicate that farmers give a positive and significant consideration to increase yield from low to medium level and to reduce the risk of crop failure from high to low and medium levels. However, the t-statistics for cost coefficient is low, resulting in lower statistical significance for the WTP values of yield and risk of crop failure attributes. The values and signs for the alternative specific constant reveal that farmers have higher preference for alternative A (check dams).

- **Base model with status quo variables:** a base model with yield, risk of crop failure and cost attributes included in the status quo alternative took the following utility function:

$$U_A = \alpha_1 mediumYieldA + \alpha_2 highYieldA + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma CostA$$
$$U_B = ASC_B + \alpha_1 mediumYieldB + \alpha_2 highYieldB + \beta_1 low\ risk\ of\ crop\ failure\ B + \beta_2 medium\ risk\ of\ crop\ failure\ B + \gamma CostB$$
$$U_c = ASC_C + \alpha_1 mediumYieldC + \alpha_2 highYieldC + \beta_1 low\ risk\ of\ crop\ failure\ C + \beta_2 medium\ risk\ of\ crop\ failure\ C + \gamma CostC$$

The attributes for the status quo alternative were based on the farmers' current crop yield, the perceived risk of crop failure (calculated based on the farmers' perception of the crop yield category from bad to good for the past four years) and the farmers' annuity cost for the current WHT that they have. The results reveal that the coefficient estimates obtained with this model is close to that obtained from the previous model, where the status quo alternative is specified as a constant. This implies that the attribute levels of the status quo alternative do not play a significant role in the farmers' decision making. Similar to the results obtained from the previous model, farmers give high importance to medium yield level and the lower levels of the risk of crop failure attributes. However, as the cost coefficient is not statistically significant, the statistical significance of the WTP estimates of the other attributes is consequently affected. The results thus reveal that the farmers might not give significant importance to the cost attribute in their decision making.

This model gave a low statistical significance for the cost coefficient. However, medium yield level and the risk of crop failure levels gave a positive and significant coefficient estimates.

The following coefficients were obtained for the variables for this model specification:

**Table 13 Multinomial logit results with status quo variables**

| **Variable** | **Coefficient estimate (t-stats)** | **WTP estimate (t-statistics)** | **WTP estimate in Euro** |
|---|---|---|---|
| ASC – alternative B | -4.39 (-10.32) | | |
| ASC – alternative C | -36.7 (-1.62) | | |
| Medium yield | 0.504 (2.92) | 5478.26 (1.15) | 246.64 (1.15) |
| High yield | 0.0177 (0.12) | 192.39 (0.12) | 8.66 (0.12) |
| Low risk of crop failure | 13.0 (13.5) | 141304 (1.00) | 6360.43 (1.00) |
| Medium risk of crop failure | 5.56 (12.02) | 60434.8 (1.00) | 2720.53 (1.00) |
| Cost | -0.000092 (-0.99) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.722<br>0.715 | | |
| FLL | -340.399 | | |
| No. of observations | 1114 | | |
| No. of individuals | 124 | | |

<u>Segmentation Models:</u>

- **Income segmentation**: income segmentation was done such that respondents with medium to high income would move away from the status quo and choose one of the WHTs from alternatives A and B. When different coefficients were used for each of the selected income categories, with lowest income category as the base, no significant effect from income segmentation was obtained.

  A model with single parameter for income categories (with lowest income category as the base) was also experimented but no significant effect was found for the WHT alternatives.

CE results from Ethiopia show that farmers give a positive and significant consideration to increase the yield from low to medium levels and to lower the risk of crop failure from high to low and medium levels. No significant effect of income variable was found however, on the choice of the farmers.

## 3.3. <u>Tunisia</u>

<u>Descriptive Statistics:</u>

Descriptive statistics for Tunisia show that all farmers are responsible for managing their own farms will about 35% farmers are also responsible for managing others' farms. 96% farmers consider WHT to be very important for their farming needs with tabia and majel considered to be more suitable. The data reveals that all farmers currently own some WHT. While most farmers have primary education, a high proportion of farmers are found to be within the age range of 41-75. 98% farmers are male and most farmers are found to have average monthly income up to 3000 Tunisian dinars. The following table provides an overview of the descriptive statistics for Tunisia.

**Table 14 Tunisia descriptive statistics for some key socio-economic variables**

| Variable | Frequency (n = 108) | Percentage |
|---|---|---|
| **Responsible for managing farms*** | | |
| - Own farm | 108 | 100.00% |
| - Others' farm | 38 | 35.2% |
| **Importance given to WHT** | | |
| - Very Important | 104 | 96.3% |
| - Important | 3 | 2.8% |
| - Neither important nor unimportant | 1 | 0.9% |
| - Unimportant | 0 | 0% |
| - Very unimportant | 0 | 0% |
| **Suitability of water harvesting technologies*** | | |
| - Jessour suitability | 22 | 20.4% |
| - Tabia suitability | 65 | 60.2% |
| - Majel suitability | 70 | 64.8% |
| **Currently own some WHT** | 108 | 100% |
| **Education** | | |
| - Illiterate | 20 | 18.5% |
| - Primary | 68 | 63.0% |
| - Secondary | 16 | 14.8% |
| - Graduate | 4 | 3.7% |
| - Post graduate | 0 | 0% |
| **Age** | | |
| - 18-25 | 0 | 0% |
| - 26-40 | 13 | 12.0% |
| - 41-55 | 33 | 30.6% |
| - 56-75 | 50 | 46.3% |
| - 75 + | 12 | 11.1% |
| **Gender** | | |
| - Male | 106 | 98.1% |
| - Female | 2 | 1.9% |
| **Income** | | |
| - < 1000 | 41 | 38.0% |
| - 1001 – 3000 | 45 | 41.7% |
| - 3001 – 5000 | 9 | 8.3% |
| - > 5000 | 13 | 12.0% |
| **Employment** | | |
| - Full time | 14 | 13.0% |
| - Part time | 25 | 23.1% |
| - Unemployed | 15 | 13.9% |
| - Retired | 11 | 10.2% |
| - House work | 0 | 0% |
| - Farm work | 43 | 39.8% |
| **Location in watershed** | | |
| - Upstream | 37 | 34.3% |
| - Midstream | 53 | 49.1% |
| - Downstream | 18 | 16.7% |
| **Choice (n = 972)** | | |
| - Alternative A (Jessour or Tabia) | 143 | 14.7% |
| - Alternative B (Jessour or Tabia with zai) | 493 | 50.7% |
| - Status quo (Current WHT) | 335 | 34.5% |
| - No choice/missing value | 1 | 0.1% |

*Variables with multiple possible responses per respondent (total can exceed 100%)

Base Models:

- **Base model without incorporating status quo variables:** a base model was specified with the status quo alternative equalling a constant and without the incorporation of the farmers' current crop yield, perceived risk of crop failure and current WHT cost in the status quo utility function. The utility functions took the following form:

$$U_A = \alpha YieldA + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma CostA$$
$$U_B = ASC_B + \alpha YieldB + \beta_3 low\ risk\ of\ crop\ failure\ B + \gamma CostB$$
$$U_c = ASC_C$$

The following results were obtained for this model:

**Table 15 Multinomial logit model without status quo variables**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| ASC – alternative B | 1.49 (4.84) | | |
| ASC – alternative C | 1.83 (3.77) | | |
| Yield | 0.00204 (10.33) | 0.149 (1.66) | 0.070 (1.66) |
| Low risk of crop failure – alternative A | 0.96 (3.17) | 700.73 (1.55) | 331.47 (1.55) |
| Medium risk of crop failure – alternative A | 0.677 (2.19) | 494.16 (1.41) | 233.79 (1.41) |
| Low risk of crop failure – alternative B | 0.701 (3.32) | 511.68 (1.56) | 242.05 (1.56) |
| Cost | -0.00137 (-1.66) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.309<br>0.30 | | |
| FLL | -737.605 | | |
| No. of observations | 971 | | |
| No. of individuals | 108 | | |

All coefficients are correctly signed and significant at 95% confidence interval while the cost coefficient while correctly signed is significant at 90% confidence interval. This implies that these attributes play a significant part in the farmers' choice of the WHT alternatives and that the farmers have a positive WTP for yield and reduction in the risk of crop failure. The WTP estimates are found to be just significant at 90% confidence interval. Positive and significant values for the alternative specific constants imply that respondents have a higher preference for these alternatives compared to the base alternative (alternative A). This finding is further supported by the descriptive statistics where more farmers are seen to choose alternatives B and C over alternative A. There is also a possibility that farmers might have a status quo bias which will be further tested in the next model which incorporates the status quo variables in the utility function.

- **Base model with status quo variables:** a base model with yield, risk of crop failure and cost attributes included in the status quo alternative took the following utility function:

$$U_A = \alpha YieldA + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma CostA$$
$$U_B = ASC_B + \alpha YieldB + \beta_3 low\ risk\ of\ crop\ failure\ B + \gamma CostB$$
$$U_c = ASC_C + \alpha YieldC + \beta_4 low\ risk\ of\ crop\ failure\ C + \beta_5 medium\ risk\ of\ crop\ failure\ C + \gamma CostC$$

The attributes for the status quo alternative were based on the farmers' current crop yield, the perceived risk of crop failure (calculated based on the farmers' perception of the crop yield category from bad to good for the past four year) and the farmers' annuity cost for the current WHT that they have. It was found that with this model specification, a very low statistical significance was obtained for the cost coefficient implying that the farmers' cost of current WHT (i.e. status quo) does not play a significant role in their choice of WHT. The following coefficients were obtained for the variables for this model specification:

**Table 16 Multinomial logit results with status quo variables**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| ASC – alternative B | 1.44 (4.69) | | |
| ASC – alternative C | 2.04 (2.33) | | |
| Yield | 0.000202 (10.3) | -4.72 (-0.13) | -2.23 (-0.13) |
| Low risk of crop failure – alternative A | 0.903 (3.00) | -21098 (-0.13) | -9981.46 (-0.13) |
| Medium risk of crop failure – alternative A | 0.611 (1.99) | -14275.7 (-0.13) | -6755.26 (-0.13) |
| Low risk of crop failure – alternative B | 0.661 (3.14) | -15443.9 (-0.13) | -7309.57 (-0.13) |
| Low risk of crop failure – alternative C | 0.754 (0.43) | -17616.8 (-0.13) | -8340.41 (-0.13) |
| Medium risk of crop failure – alternative C | 0.0239 (0.03) | -558.411 (-0.10) | -264.36 (-0.10) |
| Cost | 0.0000428 (0.00034) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.308<br>0.297 | | |
| FLL | -738.719 | | |
| No. of observations | 971 | | |
| No. of individuals | 108 | | |

It can be observed that with this model specification, the cost coefficient is not significant while the WTP estimates have the wrong sign as well as are statistically insignificant with unrealistically high values.

When separate coefficient estimates were computed for the attribute levels of the status quo alternatives, insignificant estimates were obtained for the status quo alternative, reiterating that the farmers' status quo attribute levels do not affect their decision-making. This could also indicate that the farmers might not have fully considered their current attribute levels (of the status quo) during the choice process. However, as the ASC have a significant positive value for the status quo alternative in base model 1 and the descriptive statistics reveal that about 35% farmers chose the status quo alternative, it can be inferred that there is a distinct status quo bias in this case, where many farmers decide to remain with the status quo alternative although its attribute levels are not found to be important in the choice process.

Segmentation Models:

- **Employment segmentation:** segmentation was done based on whether the respondents are full time farmers with other employment categories as the base. When a single coefficient was estimated for the full time farmer category under alternatives A and B, a positive and significant value was obtained at 95% C.I., indicating that farmers are willing to move from the status quo alternative to one of the WHT options. The coefficient estimates with this model specification are given below:

**Table 17 Multinomial logit model with employment segmentation - 1**

| **Variable** | **Coefficient estimate (t-stats)** | **WTP estimate (t-statistics)** | **WTP estimate in Euro** |
|---|---|---|---|
| ASC – alternative B | 1.48 (4.81) | | |
| ASC – alternative C | 2.41 (4.42) | | |
| Yield | 0.000204 (10.33) | 0.149 (1.67) | 0.07 (1.67) |
| Low risk of crop failure – alternative A | 0.96 (3.17) | 700.73 (1.55) | 331.64 (1.55) |
| Medium risk of crop failure – alternative A | 0.677 (2.19) | 494.16 (1.42) | 233.87 (1.42) |
| Low risk of crop failure – alternative B | 0.7 (3.32) | 510.95 (1.56) | 241.76 (1.56) |
| Cost | -0.00137 (-1.66) | | |
| Employment category – full time farmers | 1.18 (2.08) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.311<br>0.301 | | |
| FLL | -735.448 | | |
| No. of observations | 971 | | |
| No. of individuals | 108 | | |

When separate coefficients were estimated for the employment segmentation under each of the WHT alternatives, it was found that a higher and more significant estimate was obtained for alternative A (Jessour or Tabia) indicating that more full time farmers are willing to move towards this alternative from the status quo. However, significant coefficient estimates for the full time farmer under both the WHT alternatives indicate that farmers with this employment category prefer to move to either of these alternatives from the status quo, as reflected with the single coefficient model.

**Table 18 Multinomial logit model with employment segmentation - 2**

| **Variable** | **Coefficient estimate (t-stats)** | **WTP estimate (t-statistics)** | **WTP estimate in Euro** |
|---|---|---|---|
| ASC – alternative B | 1.76 (4.39) | | |
| ASC – alternative C | 2.66 (4.47) | | |
| Yield | 0.000203 (10.32) | 0.15 (1.67) | 0.07 (1.67) |
| Low risk of crop failure – alternative A | 0.961 (3.17) | 701.46 (1.55) | 331.28 (1.55) |
| Medium risk of crop failure – alternative A | 0.677 (2.19) | 494.16 (1.42) | 233.38 (1.42) |
| Low risk of crop failure – alternative B | 0.7 (3.32) | 510.95 (1.57) | 241.31 (1.57) |
| Cost | -0.00137 (-1.66) | | |
| Employment – full time farmers, alternative A | 1.66 (2.37) | | |
| Employment – full time farmers, alternative B | 1.16 (2.05) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.311<br>0.301 | | |
| FLL | -734.764 | | |
| No. of observations | 971 | | |
| No. of individuals | 108 | | |

When different coefficients were estimated for the attributes yield, risk of crop failure and cost for full-time farmers and respondents in other employment categories, it was found that full-time farmers had a higher WTP for the selected attributes than other respondents. However the WTP t-statistics were found to be slightly lower than those obtained in the ‘other employment categories’ model. This socio-economic factor however is found to have some effect on the choice of WHT alternatives as well as in the valuation of other attributes.

**Table 19 Multinomial logit model with different coefficients for full-time farmers and other employment categories**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| **Full time farmers** | | | |
| ASC – alternative B | 2.62 (5.56) | | |
| ASC – alternative C | 0.706 (0.89) | | |
| Yield | 0.000217 (9.86) | 0.16 (1.45) | 0.076 (1.45) |
| Low risk of crop failure – alternative A | 0.936 (2.27) | 693.33 (1.28) | 327.49 (1.28) |
| Medium risk of crop failure – alternative A | 0.703 (1.66) | 520.74 (1.17) | 246.02 (1.17) |
| Low risk of crop failure – alternative B | 0.711 (2.93) | 526.67 (1.34) | 248.82 (1.34) |
| Cost | -0.00135 (-1.45) | | |
| **Other employment categories** | | | |
| ASC – alternative B | 2.77 (5.79) | | |
| ASC – alternative C | 1.50 (1.89) | | |
| Yield | 0.000221 (10.22) | 0.14 (1.77) | 0.07 (1.77) |
| Low risk of crop failure – alternative A | 1.10 (2.89) | 679.01 (1.59) | 320.85 (1.59) |
| Medium risk of crop failure – alternative A | 0.744 (1.89) | 459.26 (1.38) | 217.02 (1.38) |
| Low risk of crop failure – alternative B | 0.795 (3.34) | 490.74 (1.63) | 231.89 (1.63) |
| Cost | -0.00162 (-1.77) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.318<br>0.308 | | |
| FLL | -1186.01 | | |
| No. of observations | 971 | | |
| No. of individuals | 108 | | |

- **Location effects:** different coefficients were estimated for the attributes yield, risk of crop failure and annuity cost based on the location of the farmers' village in the watershed. Three locations were selected in the survey – upstream, midstream and downstream. While 49% of the farmers were from midstream of the watershed, 34% were from upstream and about 17% from downstream.

  As more data is obtained for the midstream area of the watershed, a higher statistical significance is obtained for the coefficient estimates for this area. Examining the coefficient estimates of the attributes across the three regions of the watershed it can be observed that farmers across the three regions of the watershed give significant importance to crop yield as well as 'low risk of crop failure' for alternative B. In case of other attributes and levels, lesser statistical significance is found for the upstream and downstream farmers while the midstream farmers seem to also place significant importance on the low and medium risk of crop failure for alternative A. Across all watershed areas, lower statistical significance is found for the cost attribute indicating that this attribute has not been a significant factor in farmers' decision making.

**Table 20 Multinomial logit model with specific coefficients for farmer's locations in the watershed**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| **Upstream farmers** | | | |
| ASC – alternative B | 4.15 (6.74) | | |
| ASC – alternative C | 0.346 (0.29) | | |
| Yield | 0.000202 (9.15) | 0.0931 (2.10) | 0.44 (2.10) |
| Low risk of crop failure – alternative A | 0.816 (1.58) | 376.04 (1.32) | 177.7 (1.32) |
| Medium risk of crop failure – alternative A | 0.668 (1.27) | 307.83 (1.14) | 145.46 (1.14) |
| Low risk of crop failure – alternative B | 0.699 (2.89) | 322.12 (1.79) | 152.21 (1.79) |
| Cost | -0.00109 (-1.14) | | |
| **Midstream farmers** | | | |
| ASC – alternative B | 3.87 (6.09) | | |
| ASC – alternative C | 2.68 (2.97) | | |
| Yield | 0.000236 (10.44) | 0.109 (2.11) | 0.052 (2.11) |
| Low risk of crop failure – alternative A | 1.36 (3.24) | 626.73 (1.85) | 296.13 (1.85) |
| Medium risk of crop failure – alternative A | 0.95 (2.19) | 437.79 (1.61) | 206.85 (1.61) |
| Low risk of crop failure – alternative B | 0.832 (3.30) | 383.41 (1.82) | 181.14 (1.82) |
| Cost | -0.00168 (-1.75) | | |
| **Downstream farmers** | | | |
| ASC – alternative B | 2.67 (3.83) | | |
| ASC – alternative C | -1.33 (-0.87) | | |
| Yield | 0.000257 (8.85) | 0.118 (2.09) | 0.056 (2.09) |
| Low risk of crop failure – alternative A | 0.701 (1.34) | 323.04 (1.19) | 152.62 (1.19) |
| Medium risk of crop failure – alternative A | 0.441 (0.81) | 203.23 (0.80) | 96.02 (0.80) |
| Low risk of crop failure – alternative B | 0.761 (2.15) | 350.69 (1.42) | 165.68 (1.42) |
| Cost | -0.00216 (-1.76) | | |
| $\rho^2$ w.r.t. zero<br>$\rho^2$ w.r.t. constant | 0.356<br>0.343 | | |
| FLL | -1374.82 | | |
| No. of observations | 971 | | |
| No. of individuals | 108 | | |

Interaction Models:

- **Income interaction:** with income interaction (lowest income category as the base category) with each of the attributes yield, risk of crop failure and cost, it was found that income category 2 (Dinar 1001-3000/month) interaction with low risk of crop failure for alternative A gave a significant negative parameter estimate (at 90% C.I.) indicating that respondents with that income category are not willing to pay for a reduction in the risk of crop failure (from the high risk of crop failure category). In case of income interaction with medium risk of crop failure for alternative A just about significant parameter estimate is obtained (at 90% C.I.) indicating that this income category is not significant in the positive WTP of these attribute levels for alternative A. In case of alternative B, no significance was obtained for the income interaction with low and medium risks of crop failure under both the alternatives.

- **Employment interaction:** farming as respondents' main employment was incorporated in the WHT alternatives' utility functions through interaction with yield, risk of crop failure levels and cost. There is a significant interaction of this employment category with the crop yield attribute at 95% C.I. In case of the other attributes, significant coefficient estimates are not obtained at 95% C.I.

**Table 21 Multinomial logit model with employment interaction**

| **Variable** | **Coefficient estimate (t-stats)** | **WTP estimate (t-statistics)** | **WTP estimate in Euro** |
|---|---|---|---|
| **ASC** | | | |
| Alternative A | Fixed | | |
| Alternative B | 1.46 (4.73) | | |
| Alternative C | 1.80 (3.73) | | |
| **Yield** | 0.000164 (6.60) | 0.076 (2.13) | 0.036 (2.13) |
| **Risk of crop failure – alternative A** | | | |
| Low risk of crop failure | 0.628 (1.44) | 289.40 (1.26) | 136.81 (1.26) |
| Medium risk of cop failure | 0.469 (1.05) | 216.13 (1.00) | 102.18 (1.00) |
| **Risk of crop failure – alternative B** | | | |
| Low risk of crop failure | 0.751 (2.66) | 346.08 (1.81) | 163.62 (1.81) |
| **Cost** | -0.00217 (-2.12) | | |
| **Interaction effects with employment full time (FT) farmers** | | | |
| Yield – FT farmers | 0.0000872 (2.36) | 0.04 (1.46) | 0.019 (1.46) |
| Alt. A low risk crop failure – FT farmers | 0.508 (0.91) | 234.1 (0.80) | 110.68 (0.80) |
| Alt. A medium risk crop failure – FT farmers | 0.298 (0.52) | 137.33 (0.49) | 64.90 (0.49) |
| Alt. B low risk crop failure – FT farmers | -0.137 (-0.34) | -63.13 (-0.34) | -29.83 (-0.34) |
| Cost of WHT – FT farmers | 0.00168 (1.26) | | |
| $\rho^2$ w.r.t. zero | 0.314 | | |
| $\rho^2$ w.r.t. constant | 0.301 | | |
| FLL | -732.043 | | |
| No. of observations | 971 | | |
| No. of individuals | 108 | | |

The CE analyses for Tunisia show that farmers have a positive and significant WTP for yield and to lower the risk of crop failure. Full-time farmers are more willing to move from the status quo alternative to one of the given WHT alternatives while farmers in the midstream area of the watershed give higher importance to lowering the risk of crop failure.

### 3.4. Zambia

Descriptive Statistics:

Descriptive statistics for Zambia show that 97% farmers are responsible for managing their own farms while 12% farmers are responsible for managing others' farms. A high majority of farmers consider WHTs to be very important, with most considering 'ripping' as most suitable for their farming needs. About 40% farmers have primary education and 45% farmers have secondary education. Most farmers are found to be in the age range of 26-75. While almost 75% farmers are found to have income up to 1000 Zambian Kwacha, almost half of the farmers are unemployed. About 53% farmers choose alternative B (conservation farming with strip tillage).

**Table 22 Zambia descriptive statistics for some key socio-economic variables**

| Variable | Frequency (n = 100) | Percentage |
|---|---|---|
| **Responsible for managing farms*** | | |
| - Own farm | 97 | 97% |
| - Others' farm | 12 | 12% |
| **Importance given to WHT** | | |
| - Very Important | 66 | 66% |
| - Important | 26 | 26% |
| - Neither important nor unimportant | 7 | 7% |
| - Unimportant | 1 | 1% |
| - Very unimportant | 0 | 0% |
| **Suitability of water harvesting technologies*** | | |
| - Basins | 25 | 25% |
| - Ripping | 82 | 82% |
| - Strip tillage | 2 | 2% |
| - Zero tillage | 3 | 3% |
| - No answer | 2 | 2% |
| **Currently own some WHT** | 74 | 74% |
| **Education** | | |
| - Illiterate | 4 | 4% |
| - Primary | 40 | 40% |
| - Secondary | 45 | 45% |
| - Graduate | 11 | 11% |
| - Post graduate | 0 | 0% |
| **Age** | | |
| - 18-25 | 5 | 5% |
| - 26-40 | 29 | 29% |
| - 41-55 | 26 | 26% |
| - 56-75 | 34 | 34% |
| - 75 + | 6 | 6% |
| **Gender** | | |
| - Male | 75 | 75% |
| - Female | 25 | 25% |
| **Income** | | |
| - ≤ 300 | 51 | 51% |
| - 301 – 1000 | 25 | 25% |
| - 1001 – 5000 | 22 | 22% |
| - > 5000 | 2 | 2% |
| **Employment** | | |
| - Full time | 3 | 3% |
| - Part time | 27 | 27% |
| - Unemployed | 48 | 48% |
| - Retired | 12 | 12% |
| - House work | 2 | 2% |
| - Farm work | 8 | 8% |
| **Choice (n = 800)** | | |
| - Alternative A (CF with Magoye Ripper) | 241 | 30.1% |
| - Alternative B (CF with Strip Tillage) | 428 | 53.5% |
| - Status quo (No WHT) | 131 | 16.4% |
| - No choice/missing value | 0 | 0% |

*Variables with multiple possible responses per respondent (total can exceed 100%)

Base Models:

- **Base model without incorporating status quo variables:** a base model was specified with the status quo alternative equalling a constant and without the incorporation of the farmers' current crop yield, perceived risk of crop failure and current WHT cost in the status quo utility function. The utility functions took the following form:

$$U_A = \alpha_1 YieldA + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma_1 MaintCostA + \gamma_2 InvestCostA$$

$$U_B = ASC_B + \alpha_1 YieldB + \beta_1 low\ risk\ of\ crop\ failure\ B + \beta_2 medium\ risk\ of\ crop\ failure\ B + \gamma_1 MaintCostB + \gamma_2 InvestCostB$$

$$U_c = ASC_C$$

As the constants gave zero t-statistics value in the model estimation, a model where the constants were fixed to zero was estimated and the following results were obtained for this model:

**Table 23 Multinomial logit model without status quo variables**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| Yield | 2.56 (4.95) | 4894.84 (1.86) | 599.63 (1.86) |
| Low risk of crop failure | 0.0108 (0.07) | 20.65 (0.07) | 2.53 (0.07) |
| Medium risk of crop failure | -0.023 (-0.19) | -43.98 (-0.18) | -5.38 (-0.18) |
| Maintenance cost | 0.0186 (3.27) | | |
| Investment cost | -0.00052 (-1.79) | | |
| $\rho^2$<br>adj. $\rho^2$ | 0.442<br>0.434 | | |
| FLL | -490.253 | | |
| No. of observations | 800 | | |
| No. of individuals | 100 | | |

The above results indicate that respondents have a positive and significant WTP for 'yield' at 90% confidence interval, with respect to investment cost. The 'risk of crop failure' coefficients however, are not significant and also has a wrong sign in case of 'medium risk of crop failure', indicating that this attribute is not significant in the farmer's choice of WHT. While the investment cost show the right sign and significant coefficient estimate at 90% C.I., a positive and significant value of 'maintenance cost' could imply that this attribute is not considered a disutility by the farmers.

- **Base model with status quo variables:** a base model with yield, risk of crop failure and cost attributes included in the status quo alternative took the following utility function:

$$U_A = \alpha YieldA + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma_1 MaintCostA + \gamma_2 InvestCostA$$

$$U_B = ASC_B + \alpha YieldB + \beta_1 low\ risk\ of\ crop\ failure\ B + \beta_2 medium\ risk\ of\ crop\ failure\ B + \gamma_1 MaintCostB + \gamma_2 InvestCostB$$

$$U_c = ASC_C + \alpha YieldC + \beta_1 low\ risk\ of\ crop\ failure\ C + \beta_2 medium\ risk\ of\ crop\ failure\ C + \gamma_1 MaintCostC + \gamma_2 InvestCostC$$

The attributes for the status quo alternative were based on the farmers' current crop yield, the perceived risk of crop failure (calculated based on the farmers' perception of the crop yield category from bad to good for the past four years) and the farmers' maintenance and investment costs for the current WHT.

The following coefficients were obtained for the variables for this model specification:

**Table 24 Multinomial logit results with status quo variables**

| Variable | Coefficient estimate (t-stats) | WTP estimate (t-statistics) | WTP estimate in Euro |
|---|---|---|---|
| Yield | -1.02 (-2.09) | -1452.99 (-1.5) | -177.79 (-1.5) |
| Low risk of crop failure | -0.00386 (-0.03) | -5.49 (-0.02) | -0.67 (-0.02) |
| Medium risk of crop failure | -0.0322 (-0.26) | -45.87 (-0.26) | -5.61 (-0.26) |
| Maintenance Cost | -0.0168 (-3.24) | | |
| Investment Cost | -0.000702 (-2.32) | | |
| $\rho^2$<br>adj. $\rho^2$ | 0.43<br>0.42 | | |
| FLL | -500.21 | | |
| No. of observations | 800 | | |
| No. of individuals | 100 | | |

The above results show wrong sign for 'yield' as well as 'risk of crop failure' attributes implying that this model specification does not provide coefficient estimates as expected and hence the model where status quo alternative is specified only as a constant could be more preferable.

Segmentation Models:

- **Income segmentation**: income segmentation on model where status quo alternative is specified as a constant revealed that farmers with low and lower middle income chose alternative B (the cheaper alternative). The utility functions took the following form:

$$U_A = \alpha_1 YieldA + \beta_1 low\ risk\ of\ crop\ failure\ A + \beta_2 medium\ risk\ of\ crop\ failure\ A + \gamma_1 MaintCostA + \gamma_2 InvestCostA$$

$$U_B = ASC_B + \alpha_1 YieldB + \beta_1 low\ risk\ of\ crop\ failure\ B + \beta_2 medium\ risk\ of\ crop\ failure\ B + \gamma_1 MaintCostB + \gamma_2 InvestCostB + \eta_1 Income1 + \eta_2 Income2$$

$$U_c = ASC_C$$

The following results were obtained for this model:

**Table 25 Multinomial logit model with income segmentation**

| **Variable** | **Coefficient estimate (t-stats)** | **WTP estimate (t-statistics)** | **WTP estimate in Euro** |
|---|---|---|---|
| Yield | 2.49 (4.78) | 4715.91 (1.87) | 576.98 (1.87) |
| Low risk of crop failure | 0.0106 (0.07) | 20.076 (0.07) | 2.46 (0.07) |
| Medium risk of crop failure | -0.0232 (-0.19) | -43.94 (-0.186) | -5.43 (-0.186) |
| Maintenance Cost | 0.0217 (3.52) | 41.099 (1.88) | 5.08 (1.88) |
| Investment Cost | -0.00053 (-1.8) | | |
| Income<br>≤ 300<br>301-1000 | <br>0.383 (0.89)<br>0.763 (1.54) | | |
| $\rho^2$<br>adj. $\rho^2$ | 0.444<br>0.433 | | |
| FLL | -489.049 | | |
| No. of observations | 800 | | |
| No. of individuals | 100 | | |

The results show that farmers with income level 301-1000 Kwacha per month have a higher preference for alternative B. As only 2% farmers have income >5000 Kwacha per month and 22% farmers have income from 1001-5000 Kwacha per month, these income categories were excluded in the model. Hence the coefficients for the income categories in the model are in relation to the higher income categories.

Summarising the results obtained from the Zambia CE analyses, it can be noted that farmers have a positive and significant willingness to pay for yield when the status quo alternative is specified as a constant. The model where the status quo attributes are incorporated in the utility function, does not provide the expected signs for coefficient estimates for yield and risk of crop failure, indicating that this is not a suitable model specification, in this case. It was also found that farmers with lower income categories are more likely to choose alternative B, which is relatively cheaper.

# 4 Discussion

The stakeholder WHT selection workshops in each of the countries elicited a variety of criteria that participants ranked as most important (Table 26). Overall, the most important criterion was considered to be improved crop yield. In second place, environmental criteria (increase biodiversity, reduce soil erosion) were deemed important. Increased income and profitability was considered third in importance. Here, it could be noted that for a WH technology to lead to increased income/profitability, its investment costs are probably internalised in the assessment, although in Tunisia the latter were considered separately. Adaptability and crop diversification criteria in Ethiopia and Burkina Faso could be linked to risk management strategies. Social criteria (acceptability and benefits to women and youth in Ethiopia, and unemployment reduction in Tunisia) were also considered of importance. Table 27 shows the WH technologies prioritised in each of the countries based on these criteria.

In order to link the above criteria to the WTP estimates elicited from the Choice Experiment, they were grouped into two categories, namely those criteria most clearly linked to improved yield and income generation, and those leading to risk reduction, including through enhanced system resilience through environmental effects. Table 28 shows a comparison of the relative weight and WTP estimates for these two attribute areas of WH technologies.

**Table 26 Highest-ranked criteria from stakeholder WHT selection workshops**

| Criteria rank | **Burkina Faso** | **Ethiopia** | **Tunisia[a]** | **Tunisia[b]** | **Zambia** |
|---|---|---|---|---|---|
| 1 | Improve yield | Improve productivity | Conserving water & soil | Increasing crop yields | Not clear |
| 2 | Increase biodiversity | Protect against erosion, increase arable land and reclaim plantation | Conserving biodiversity | Increasing farm income | |
| 3 | Give income | Adaptable and socially acceptable | Groundwater recharge | Construction and maintenance costs | |
| 4 | Crop Diversification | Profitable | Increasing crop yields | | |
| 5 | Improve water availability | Beneficial to females and youth | Increasing farm income | | |
| 6 | | Adaptable to different ecological conditions | Unemployment reduction | | |

[a] Based on environmental, economic and social criteria; [b] Economic criteria only. Source: Sawadogo et al. (2013).

**Table 27 WHT selected for test implementation in the four study sites**

| | **Burkina Faso** | **Ethiopia** | **Zambia** | **Tunisia** |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1st selected WHT | Zaï | Series of Hillside Cistern with bench terraces | Minimum-Till Basin Method | Jessour |
| 2nd selected WHT | Stones lines | Percolation/sediment storage ponds with hand dug wells | Conservation Tillage with Magoye Ripper | Gabion check dam |
| 3rd selected WHT | Magoye Ripper to combine with use of compost manure | Check dams | Strip Tillage Conservation Farming | Tabia |
| 4th selected WHT | Talya tray was a special choice of women for an experimentation to useful tree | Soil improvement methods (Mulching, Compost, EM) | Animal Draft Zero-Tillage | Cistern |
| 5th selected WHT | | | | Recharge well |

**Table 28 Comparison of aggregated weights attached to productivity and risk reduction impacts of WHT from stakeholder workshops and WTP elicited from CE models without status quo for highest attribute levels**

| | **Burkina Faso** | | **Ethiopia** | | **Tunisia** | | **Zambia** | |
|---|---|---|---|---|---|---|---|---|
| | Weight | WTP | Weight | WTP | Weight | WTP | Weight | WTP |
| Increased yield | 56% | 1353 | 35% | 8.3 | 37% | 0.1 | n.a. | 600 |
| Risk reduction | 44% | 75 | 65% | 6502 | 63% | 287* | n.a. | 2.5 |

*This WTP is an average of the WTP for low risk for alternative A and WTP for low risk of alternative B

The comparison shows that in the most arid environments (Ethiopia and Tunisia), predominant weight is given to risk reduction, particularly in Tunisia where WTP for increased yield is negligible. In contrast, in more sub-humid environments (Burkina Faso and Zambia), farmers are primarily concerned with the yield increase potential of WHT rather than risk reduction. Relative preferences are quite pronounced for the WTP estimates, although the very high WTP estimates for increased yield in Burkina Faso and risk reduction in Ethiopia seem to be overestimations.

While the CE as conducted in WAHARA generated important insights into the trade-offs made by farmers across all study sites, there is still a further need to understand farmer decision-making under environmental stresses, e.g. drought (Keshavarz and Karami, 2014). These authors found that different patterns of coping responses were utilized by farmers in different stages of drought that expanded from short-term adjustment to long-term adaptation, suggesting that farmer's preferences for WHT attributes could be different depending on the level of environmental stress experienced. Notwithstanding, our analyses could not establish a relation between low yield levels in previous years and WTP estimates for attributes of WH technologies.

Only the Tunisian results included some specification of spatial variation in preferences. Such preferences could well be important as WHT are commonly adapted to specific environmental conditions. Whereas we found such effect based on respondents' location, further exploring such spatial preferences could be done by looking at attributes that vary spatially (e.g. García-Lorrente et al., 2012).

The CE results across all study sites except Burkina Faso show that farmers have a positive WTP for yield and to lower the risk of crop failure. These factors are therefore found to be important in farmers' selection of WHTs and in its application. In the case of Burkina Faso, a specific difficulty may have been that farmers were asked to consider the status quo as having no WHT, whereas in reality most respondents indicated already implementing WHT. Such hypothetical situation may have been difficult for respondents to relate to. While the CE analyses have provided some insight into farmers' decision making, a richer dataset or further information on the cause of choosing a particular alternative would be required to further interpret CE results and/or make the CE analyses more meaningful.

# 5 Conclusion

Choice experiments are commonly applied to evaluate respondents' preferences and are applied when multiple attributes need to be simultaneously evaluated. However, when respondents have little prior experience of the technique, a robust data set is needed for better model analyses. In most of the study sites however, it is found that reliable estimates of model fit have been obtained and the farmers have shown a positive willingness to pay to increase crop yield and reduce the risk of crop failure. In study sites where WTP estimates are seen to be statistically insignificant or with a negative sign, a follow-up survey could perhaps provide a better insight on the decision-making method employed by the farmers.


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## Annexes:

### A. Guidelines for selection of alternatives, attributes and attribute levels for the CE design

**<u>Guidelines for selection of alternatives, attributes and attribute levels for CE design</u>**

This document is intended to help the SS partners in their selection of alternatives, attributes and attribute levels for the choice experiment design. Please go through the following document carefully and complete each section.

1. <u>Selection of alternatives:</u> please select two WHTs that you would like to test with the CE survey. One of these WHTs should be a 'new' WHT. Please also indicate what is the status quo in the study site – for example, do farmers currently employ some kind of WHT which varies across different sites/farmers ('multiple WHT') or is 'no WHT' the status quo amongst most of the farmers in the study site?

   Please complete the following table:

| | Please specify |
|---|---|
| Indigenous WHT to be tested with CE | |
| 'New' WHT to be tested with CE | |
| Status quo alternative | |

2. <u>Selection of attributes and attribute levels:</u> crop yield, cost of WHT and risk of crop failure under each of the WHTs as well as the status quo, are the selected attributes by the Leeds CE team. If these attributes are relevant for your study site, please provide their levels. Please also indicate if there are any other more significant attributes that you think would be important to include in the choice experiment.

   For each of the attributes, please provide three different levels that it can take under each of the WHTs. Where 'no WHT' is the status quo or different farmers across the study site currently use different WHTs, this information need not be provided for the status quo alternative.

   a. **Crop yield:** please provide three different levels of crop yield. The levels can vary based on the different areas, rainfall years or other criteria and can be informed by the range that the attribute can take.

      Please complete the following table:

| | Crop yield | | |
|---|---|---|---|
| | Level 1 | Level 2 | Level 3 |
| Indigenous WHT | | | |
| 'New' WHT | | | |
| Status quo | | | |

**b.** **Cost of WHT:** the cost of WHT can be differentiated into initial investment cost and regular maintenance cost. These costs can be combined to form the annuity cost, once the life of the WHT and the interest rates are known.

For example, with an interest rate of 7.25% and the life of the technology 25 years, the investment cost of $1150 and maintenance cost of $125/year, the annuity cost can be calculated as follows:

$$\frac{1150 + 125\left(\left(1-(1+.0725)^{-25}\right)/.0725\right)}{25} = \$102.98$$

It has been considered by the Leeds CE team that the annuity cost of the WHT can be used as the cost of the technology. Please let the Leeds CE team know whether this is relevant in your case and would be easy for the respondents to understand. Please provide the following information for each of WHTs in the CE as well as the status quo, in case of a status quo where a specific WHT is currently applied by most of the farmers. Where 'no WHT' is the status quo or different farmers across the study site currently use different WHTs, this information need not be provided for the status quo alternative. Please provide 3 different levels that investment and maintenance cost can take for each of the alternatives.

| | **Investment cost** | | | **Maintenance cost** | | | **Life of the technology** | **Interest rate** |
|---|---|---|---|---|---|---|---|---|
| | Level 1 | Level 2 | Level 3 | Level 1 | Level 2 | Level 3 | | |
| Indigenous WHT | | | | | | | | |
| 'New' WHT | | | | | | | | |
| Status quo | | | | | | | | |

**c.** **Risk of crop failure:** for each of the alternatives in the choice experiment, the risk of crop failure can be computed using a) the information on the probability of the occurrence of the factor/s of crop failure (such as rainfall) and, b) probability of risk of crop failure based on the factor of crop failure.

The following tables provide an example where the type of rainfall year is a factor of risk of crop failure. Please study these tables carefully and provide similar information for the factor/s of risk of crop failure applicable in your case as well as the probabilities in each case.

Please indicate the probabilities of wet, normal and dry years (probabilities of factor/s of risk of crop failure) – in case historical data is unavailable, this can be based on expert opinion:

| | Wet year | Normal year | Dry year |
|---|---|---|---|
| Probability of event | | | |

Please indicate the probability of the event for situations in case of indigenous WHT. For example, in the first cell of the table, please indicate the probability of a 'high risk of crop failure' (in percentage) when it is a wet year when using indigenous WHT:

| | High risk of crop failure | Medium risk of crop failure | Low risk of crop failure |
|---|---|---|---|
| Wet year | | | |
| Normal year | | | |
| Dry year | | | |

Please indicate the probability of the event for the following situations in case of 'new' WHT:

| | High risk of crop failure | Medium risk of crop failure | Low risk of crop failure |
|---|---|---|---|
| Wet year | | | |
| Normal year | | | |
| Dry year | | | |

**d.** **Other attributes:** please specify any other attribute that you consider to be important to incorporate in the CE survey. Please also provide 2-3 levels of the chosen attribute for the indigenous and 'new' WHTs as well as the status quo alternative.

## B. Choice card set and survey form

The following is the choice card and the CE survey form for Burkina Faso:

# Choice Experiment Questionnaire – Burkina Faso

Questionnaire number:

Interviewer's name and date:

## Objective of the survey (state to the respondents):

**This survey is being conducted to know your preferences for the different water harvesting technologies (WHTs) based on their various characteristics. We would also like to know your attitudes towards WHTs in general. For this purpose, we would like to ask you some questions and we thank you in advance for your co-operation.**

## Q1. Farmland questions

1. What is your name: ______________________________________________

2. Do you hold any farmland

   a. Yes ☐
   b. No ☐

   If Yes, please specify the area of the farmland held ______________________

3. Are you responsible for managing farms of your wife/other family members

   a. Yes ☐
   b. No ☐

   If Yes, please specify the area of the farmland ______________________

4. What crops and trees do you grow in your farm

   ______________________________________________

5. Please indicate the current crop yield (kg/ha) in your farm

   ______________________________________________

6. Please specify the village of your farmland (Enumerators please also specify the region of the village)

   ______________________________________________

## Q2. Information on the choice experiment and stated preference choice scenarios

In order to know your preferences for the WHTs, we would like to offer you a series of choice scenarios where you will be asked to indicate your preferred choice. Please bear in mind that this exercise is not associated with any governmental policy and is solely for research purposes only. Please compare each of the alternatives based on all the characteristics provided, choosing the 'status quo' alternative only when it is your preferred alternative.

Each of the alternatives in the choice set is characterised by attributes – 'crop yield', 'risk of crop failure' and 'annuity cost'.

Definitions:
**Crop yield** indicates the actual crop yield in kg/ha for each of the different WHTs.
**Risk of crop failure** indicates the probability of crop failure for each of the WHTs based on different rainfall years (dry, normal and wet). **High** risk indicates >60% of crops fail, **medium** risk indicates 40-60% of crops fail and **low** risk indicates <40% of crops fail.
**Annuity cost** refers to the cost associated with each WHTs in FCFA per year considering the fixed 'establishment' cost and the variable 'maintenance' cost, as well as the life-span of the technology and the interest rate. Please bear in mind this includes any opportunity cost resulting from 'paid employment' lost by working to construct the WHT.

**INTERVIEWER: PLEASE SHOW CHOICE CARDS SUCCESSIVELY TO THE RESPONDENTS AND NOTE DOWN THEIR PREFERENCES IN THE TABLE**

**For each of the following choice scenarios, please select the preferred alternative (Interviewer: Please note the selected options for choice scenarios 1-9 in the following table):**

| | OPTION A | OPTION B | STATUS QUO |
|---|---|---|---|
| **Scenario 1** | | | |
| **Scenario 2** | | | |
| **Scenario 3** | | | |
| **Scenario 4** | | | |
| **Scenario 5** | | | |
| **Scenario 6** | | | |
| **Scenario 7** | | | |
| **Scenario 8** | | | |
| **Scenario 9** | | | |

IF THE RESPONDENT HAS CONSISTENTLY CHOSEN THE 'STATUS QUO' OPTION, PLEASE ASK THEIR REASONS FOR DOING SO

______________________________________________________________

**Q3. Water harvesting technology attitudinal questions**

1. Do you use any water harvesting technologies in your farm

    a. Yes ☐
    b. No (go to question 3) ☐

    If Yes, please specify which ____________________

2. Please indicate the establishment and maintenance cost (per ha) for **each** of the current water harvesting technologies that you use in your farm

    Establishment cost: ____________________

    Maintenance cost (per year, per WHT): ____________________

3. How important do you consider water harvesting technologies as a means to improving crop yield and farmers' income

    a. Very important ☐
    b. Important ☐
    c. Neither important nor unimportant ☐
    d. Unimportant ☐
    e. Very unimportant ☐

4. Please specify which water harvesting technologies do you consider more suitable for your farming needs

    ____________________

5. How would you categorise crop yield in your farm for the last four years (2009-2012)? (Please mark one category per year)

| | Good | Medium | Bad |
|---|---|---|---|
| **2009** | | | |
| **2010** | | | |
| **2011** | | | |
| **2012** | | | |

**Q4. Socio-economic characteristics**

1. What is your highest education level:

   a. Illiterate ☐
   b. Primary School ☐
   c. Secondary School ☐
   d. Graduate ☐
   e. Postgraduate ☐

2. What is your age group:

   a. 18 – 25 ☐
   b. 26 – 40 ☐
   c. 41 – 55 ☐
   d. 56 – 75 ☐
   e. 75+ ☐

3. Gender:

   a. Male ☐
   b. Female ☐

4. Net household monthly income (category):

   a. < 1000 ☐
   b. 1001 – 3000 ☐
   c. 3001 – 5000 ☐
   d. > 5000 ☐

5. Employment status:

   a. Full-time employment ☐
   b. Part-time employment ☐
   c. Unemployed ☐
   d. Retired ☐
   e. House work ☐
   f. Farm work ☐

**Choice cards for Burkina Faso**

| Scenario 1 | Option A | Option B | Status Quo |
|---|---|---|---|
| Crop yield | 0-800 kg/ha | 0-500 kg/ha | As now |
| Risk of crop failure | High in normal year | Medium in normal year | |
| Annuity cost | 15000 FCFA | 12000 FCFA | |
| | | | |
| **Scenario 2** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 0-800 kg/ha | 0-500 kg/ha | As now |
| Risk of crop failure | Medium in normal year | Low in normal year | |
| Annuity cost | 45000 FCFA | 20000 FCFA | |
| | | | |
| **Scenario 3** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 0-800 kg/ha | 0-500 kg/ha | As now |
| Risk of crop failure | Low in normal year | High in normal year | |
| Annuity cost | 30000 FCFA | 15000 FCFA | |
| | | | |
| **Scenario 4** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 800-1800 kg/ha | 500-1500 kg/ha | As now |
| Risk of crop failure | High in normal year | Medium in normal year | |
| Annuity cost | 30000 FCFA | 15000 FCFA | |
| | | | |
| **Scenario 5** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 800-1800 kg/ha | 500-1500 kg/ha | As now |
| Risk of crop failure | Medium in normal year | Low in normal year | |
| Annuity cost | 15000 FCFA | 12000 FCFA | |
| | | | |
| **Scenario 6** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 800-1800 kg/ha | 500-1500 kg/ha | As now |
| Risk of crop failure | Low in normal year | High in normal year | |
| Annuity cost | 45000 FCFA | 20000 FCFA | |
| | | | |
| **Scenario 7** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 1800-2400 kg/ha | 1500-2100 kg/ha | As now |
| Risk of crop failure | High in normal year | Medium in normal year | |
| Annuity cost | 45000 FCFA | 20000 FCFA | |
| | | | |
| **Scenario 8** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 1800-2400 kg/ha | 1500-2100 kg/ha | As now |
| Risk of crop failure | Medium in normal year | Low in normal year | |
| Annuity cost | 30000 FCFA | 15000 FCFA | |
| | | | |
| **Scenario 9** | **Option A** | **Option B** | **Status Quo** |
| Crop yield | 1800-2400 kg/ha | 1500-2100 kg/ha | As now |
| Risk of crop failure | Low in normal year | High in normal year | |
| Annuity cost | 15000 FCFA | 12000 FCFA | |

## C. CE Guidelines

The following is the CE guidelines provided to the study site Burkina Faso. A similar guidelines was also provided to all other study sites.

**<u>Guidelines for the Choice Experiment Survey - Burkina Faso</u>**

1. Please follow the questionnaire format/sequence as provided. If any changes are made to the questionnaire format during translation or survey, please inform these to the Leeds CE team.
2. Please try to divide the total respondents' sample across the different parts of the selected area as evenly as possible. For example, where 100 farmers are interviewed, please ensure that equal number of farmers come from each of the selected parts of the survey area.
3. Please interview each farmer only once though they may have farms in different parts of the survey area.
4. Please specify to the farmers that the 'status quo' alternative refers to 'no WHT' as is largely prevalent in the area.
5. Questions related to the farmland pertain to the specific interviewed area. For example, if the farmer has two farms on different sites of the selected survey area then the farmland question relates specifically for the farm in the interviewed area.
6. The interviewers should be clear that the purpose of the CE survey is to elicit farmers' choices by asking them to go through different choice scenarios where they are asked to compare the different alternatives and attributes and select their preferred alternative by making appropriate attribute trade-offs.
7. The interviewers should be well-trained in the CE survey technique
    a. They should understand the objective of the survey and the definitions of the attributes, as provided in the questionnaire and the summary report, as well as the status quo alternative
    b. The interviewers should explain the objectives of the survey and definitions of the attributes to the farmers, as provided in the questionnaire
    c. The interviewers should be able to explain to the farmers what is required during the choice exercise
    d. Option A and Option B in the choice scenarios are deliberately 'unlabelled'. The interviewers should not detail what these specifically are to the farmers.
    e. The interviewers should not force or induce farmers to select a particular alternative during the choice exercise
    f. The interviewers should encourage farmers to respond to every choice scenario in the CE survey

g. The interviewers should specify to the farmers that they should select the ‘status quo’ alternative only when it is the most preferred alternative in the choice scenario
h. If the choice cards are used for several CE interviews, it is important that the interviewers must not mark the farmers’ choices on the choice card itself but rather on the CE table provided in the questionnaire as marking on the choice card could result in influencing other farmers’ decisions

8. It is better to interview each farmer separately and one at a time. Where a group of farmers is present when one is interviewed there is a tendency between farmers to discuss with each other which may result in joint decision-making of the farmers (rather than individual decision-making) as well as farmers influencing each other. It may also increase the total survey time resulting from a discussion started amongst the farmers.
9. Please specify the Leeds CE team of the exact method of CE survey technique employed during the survey.